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SUBJECT: WWII BLOCK DIAGRAMS MEETING OF APRIL 24, 1952

To: WWII Planning Group

From: W. A. Hosier

Date: May 5, 1952

Abstract: This note summarizes the discussion at the above meeting for the benefit of those who may wish to trace the course of thought on the subject.

Present:			
	G. R. Briggs	J. W. Forrester	R. P. Mayer
	D. R. Brown	H.R.J. Grosch	I. S. Reed
	S. H. Dodd	W. A. Hosier	N. H. Taylor
	H. Fahnestock	R. C. Jeffrey	

This meeting was opened by I. Reed's explanation of the previously outlined four-order computer, supplementing the unnumbered memorandum by himself and R. Jeffrey which was distributed at the meeting.

Reed was asked how he determined the number and size of registers to use after settling on word length and number of orders; he replied that the technique was substantially one of trial and error, starting with a generous number of registers and paring this number down by whatever logical economies were possible.

The control, probably the most distinguishing feature of Reed's machine, was directed by a 3-bit counter (designated the "F-counter"), which, however, did not simply count a cycle of 8, but rather a cycle with four alternate "loops" corresponding to the machine's four orders. Mayer emphasized the more economical use of components in such an arrangement as compared with the time-pulse distributor and diode matrix of WWI. It was suggested that Reed develop some figures to indicate the switching times necessary in a crystal network of the sort envisaged in this machine.

A discussion of the merits of Boolean Algebraic analysis ensued, especially as applied to synthesis of computers; it was agreed that one of the ways in which it helps most is to keep track of many variables in complex systems, and thus reduce the number of oversights in signal-tracing.

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J. Forrester then turned the discussion to the importance of reliability, saying that if need be, the air defense area covered or the number of functions performed by the computer might be reduced in the interests thereof.

He cited figures on present performance of naval radar equipment: shipborne sets 14 db below specifications; airborne sets having a "half-life" of 8 hours, although the average tube life is 1400 hours and average life of other components is 5000 hours; aircraft unavailable for combat principally because of faulty electronic equipment.

This sorry picture, he pointed out, can largely be blamed on the armed forces' procurement customs and manufacturers' sales policy: equipment ordered on the basis of a certain guaranteed performance, often obtained by marginal design and realizable only under expert operation.

In view of numerous pressures for performance - for speed, versatility, etc., Mr. Forrester feels that it is vital for the laboratory administrators to be spokesmen for reliability, and prevent flashier "selling points" from usurping the claims of this homely virtue. To aid in assessing the reliability of designs, he suggested that S. Dodd and others of the WWI crew provide such life data as are available for WWI components: tubes, diodes, resistors, capacitors, pulse transformers, soldered joints, etc., together with such qualifying data as may be pertinent - e.g., the number of such components in operation, type of function in which components failed, etc.

S. Dodd commented that current data of this sort is more accurate than earlier data, thanks to the greater variety of programs now being run, and refinements of error detection. He asked whether faults detected in incidental preventive maintenance - e.g., tap shorts in tubes removed for testing while the machine was inoperative for other reasons - should be included with breakdowns during operation. It was agreed that they should be separated; in fact, N. Taylor said that in some figures collected in the past, three categories of failure were admitted: during operation, during marginal checking, and other. He commented that vibrational marginal checking for things like tap shorts has been considered, but generally rejected as requiring too much auxiliary equipment and possibly likely to cause some failures which otherwise would never occur.

The remainder of the meeting was occupied with general considerations of ways to achieve reliability.

To answer the possible objection that a disproportionate emphasis on reliability would make cost prohibitive, J. Forrester pointed out that initial cost of the computer is a minor item in the total expense of an air defense network: that maintenance and operation costs far surpass it, not to mention telephone line rentals.

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I. Reed suggested that the central computer of an air defense system could perhaps operate slower, and therefore more reliably, if some of its preliminary conversions and correlations could be decentralized and done by smaller, special-purpose computers nearer to the radar inputs; at least he thought the general issue of centralization was one which needed a more thorough statistical analysis than it has hitherto received.

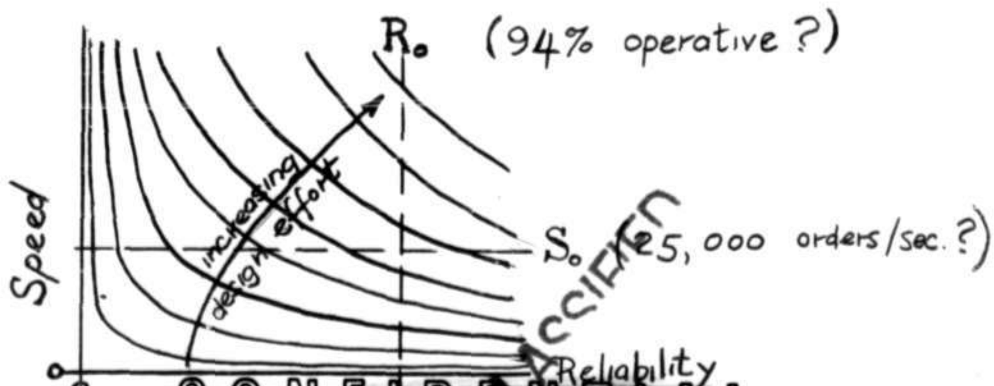
N. Taylor pointed out that something like 15 seconds are available between successive instructions to interceptor aircraft, and that to achieve maximum reliability we should not impose higher speed requirements on the computer than are really necessary.

If one wishes to build computer B to operate twice as fast as computer A, the question was raised, does this mean that machine B must have twice as many components as machine A? If so, it was agreed that the reliability per operation of the slower, simpler machine is probably better.

Of course, the relationship of speed to complexity is not so simple. It may be true that the numbers of certain components are more or less proportional to speed; however, as Mr. Forrester pointed out, each such component might be thought of as being associated with others so that using n such elements involves using other equipment in a quantity an + b - i.e., some equipment of which about the same amount is used for all values of n within reason, and some of which the amount is more or less proportional to n. The relative complexity of a and b would ultimately determine how much was to be gained by slowing down and simplifying the machine - or by making it faster and more complex. (Compare in this regard the rough figures for CADAC and WWI, in the report of the block diagrams meeting of May 1, 1952.)

H. Grosch argued the case for using several reasonably reliable computers in multiplex rather than one super-reliable one; Forrester's reply to this was that, first, the extra switching equipment needed for keeping a "stand-by" system working would in itself complicate maintenance and reduce reliability; second, that under usual field conditions, one or more standby machines would doubtless be cannibalized for parts, with the result of not being able to stand by when needed.

In general, Mr. Forrester reflected, a family of speed-vs.-reliability curves can be visualized with design effort as a parameter:



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An acceptable computer for air defense purposes has certain minima, S_o and R_o, of tolerable speed and reliability; once our design effort has brought us to a curve in the "green pastures" where we exceed these minima, other considerations can determine what point of the curve is best.

SIGNED W. A. Hosier
W. A. Hosier

APPROVED N. H. Taylor
N. H. Taylor

WAH/cp

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